The constructional solutions for absorption of vibration in special vehicles operated in terrain

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Abstract. The paper presents possibilities of usage of innovative constructions in special vehicles for absorbing of vibrations. The regular vehicles, as passenger cars, have many solutions of suspensions. Depending on purpose of the car it can be generally grouped for soft suspensions with destination for passenger, family cars and hard suspensions for sports cars. According to safety and comfort requirements there are constant research on compromise solution. Thus we have mechanically, hydraulically, pneumatically and mechatronic constructions of suspensions. For the passenger cars the project assumptions are much easier to reach. It is assumed that vehicle will be driven on paved the way with carrying load less than construction parameters. For the special vehicles such assumptions can't be done. The vehicles can be used as off road on natural ground and very often with extra load. Thus the universal solutions for suspensions are not good enough. Taking into consideration that special vehicles mostly are constructed basing on regular frame and truck chassis the possible solutions become very narrow. Thus the paper presents an approach with intermediate frame. The analysis presented are just small part of work packages of research programme Demonstrator + Supporting scientific research and development works in demonstration scale, the title of the project is Develop High Mobility Wheeled Platform for special applications (no. WND-DEM-1-325/00 KoPlatWysMob).

Keywords: high mobility platform, absorption of vibration, intermediate frame.

1. Introduction

Vibration as a result of vehicle dynamics in special vehicles are combined with movements and vibrations resulting from the deflection of the body. The ratio of the sprung and unsprung masses is much different than for passenger cars. Thus the vibrations have to considered in another sense. The heavy trucks have multiple more weight. The effect of the vibration has to be considered due to internal and external propagation. The human exposure to vibration is still important for the operator but heavy masses generate external vibration affecting roads and buildings [1-3]. If we consider the dynamic loads caused by vehicle-pavement interaction are either moving loads or random loads. There are some publications reporting number of field measurements and theoretical investigations, which have shown that vehicle vibration-induced pavement loads are moving stochastic loads [4, 5]. The random response of pavement to moving stochastic loads can be obtained using the general theory developed by Sun [6] and Sun and Greenberg [7]. The researchers concluded that vibrations of vehicles were related primarily to pavement surface roughness, vehicle velocity and suspension types [8-10]. Also it is evident that a significant relationship exists between vehicle suspension and dynamic tire loads. It is important for both vehicle and pavement engineers to realize that there is a need to reduce dynamic pavement loads through optimizing vehicle suspension by their common efforts. It is also imperative that, if the entire system (vehicle-pavement) is to be optimized, highway pavements must receive considerable attention in vehicle suspension design, and vice versa [11].

The issues of absorption of vibration, vehicle dynamics and stability in terrain become big factors for developing project and new constructions. Especially for special vehicles operated in different environment and on irregular ground surface. These type of vehicles have large scope of loads, from general cargo to concrete. It can be designed, developed, produced and installed truck bodies and trailers for any kind of use according to special and individual requirements.

2. Frame and chassis vs body

Due to the forces and the reactions occurring between the sprung and unsprung masses of the vehicles the elements connecting the wheels and axles of the vehicle, the frame and the body play very important role. In trucks, mass ratios of these elements necessitate consideration of dynamic phenomena in another scope. In case of special vehicles there is a need to provide appropriate base to carry the body and to protect it from damages caused by vibrations. In particular, it concerns firefighting vehicles whose weight and mass distribution may vary depending on tanks volume and quantity of required equipment that has to be transported in the vehicle. There is then the need to use intermediate frames as structural elements compensating the differences in the masses and in the dynamics and range of motion the body. The suspension system comprises the interface between the frame and the road surface. But it has to be considered forces generated between frame and body.

A vehicle construction is complicated mechanical system. It consists of a multiple spring-mass-damper system that in reality has six degrees of freedom. Due to the knowledge that the effective transverse and longitudinal stiffnesses of the suspension are much greater than the vertical stiffness, lateral and transverse compliance cannot generally be disregarded and may have a large impact on the vehicle dynamics. The primary motion of the vehicle mass is in the vertical direction. However, because of the separate springs and dampers at the front and rear, rotational motion usually results.

3. Intermediate frame

The requirements for the intermediate frame are focused on loads (goods) or vehicle use and stability of body (superstructure). As far as vehicle application or load requirements determine shape and volume of the construction, the stability will be realized as stiffness and spring/damping properties of the connections. Torsionally stiff bodies may not affect the torsional flexibility of the chassis frame. They must be connected to the chassis so that they are torsionally flexible in accordance with the specifications of the body/equipment mounting directives. Fixed bearings and pivot bearings are used for this purpose. Due to types of special bodies the mounting of implements and bodies become very important [12].

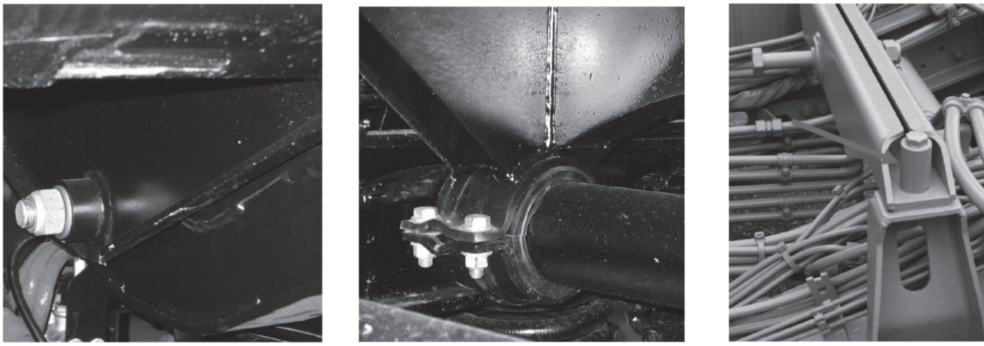
As the example the Mercedes-Benz Unimogs can be described. Its properties are excel in all terrains. Whether on or off-road, Unimog can carry people and load to every place that they are needed. Unimogs master gradients is up to 100 % for 45° climbing capability. The advantages include low-pressure tyres, long travel coil springs and large-volume telescopic shock absorbers. A Central Tire Inflation System enables the driver to adjust the tyre pressure while travelling, for better traction on all kinds of surfaces and in any terrain. These advantages result from the flexible ladder-type frame for high rigidity on the road and its very good torsional flexibility off-road. The ladder-type frame with its tubular cross members provides outstanding torsional flexibility and elasticity for tasks involving difficult terrain [13].

Concerning the floor assembly used for mounting a body to a chassis it can be supplied by the plant or delivered as a replacement part for retrofitting. The floor assembly allows torsion-free mounting of bodies. It has been specially developed to minimize the stress on the body, even when the frame is subjected to extreme torsion. Fittings applied in order to mount the bodies are as follows:

– Front crossmember with pivot bearing,
– Fixed bearings for mounting on the fifth/sixth frame crossmember,
– Rear crossmember with pivot bearing.

The different types of intermediate frame have been depicted in Fig. 2.

The presentation of body mounting on vehicle frame have been depicted in Figs. 3 and 4.



a) Pivot bearing b) Fixed bearing c) Crossmember attachment with elastic bushing

Fig. 1. Type of connection elements [12]

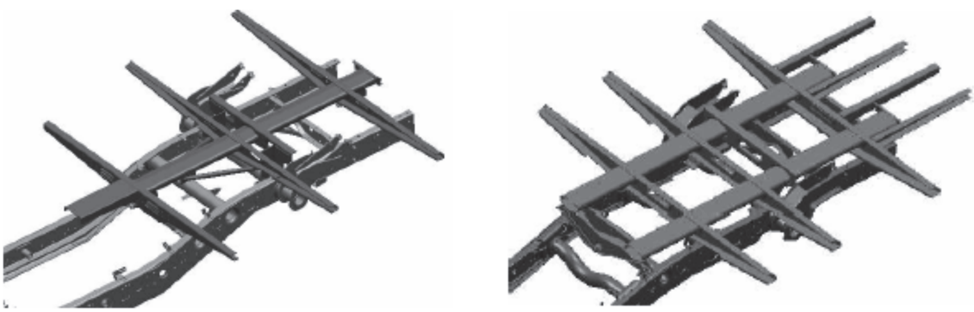


Fig. 2. Different types of intermediate frame [12]

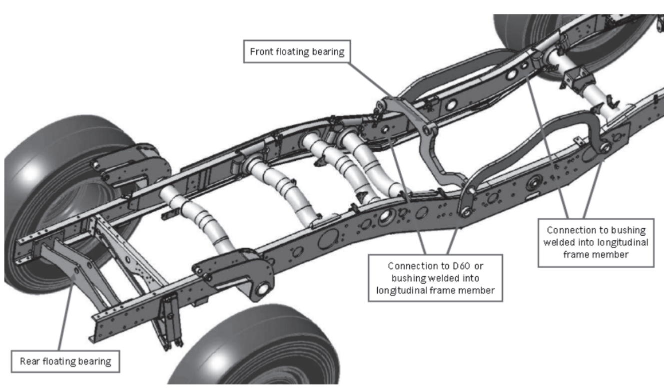


Fig. 3. Example of body mounting for heavy bodies on vehicles with closed longitudinal frame members [12]

In addition to the 3-point mounting for cab, engine and transmission, the heavy-duty ladder-type frame is also fitted with a double 3-point mounting system to ensure twist and strain-free mounting for superstructures. They are fitted at positions suitable for passing on thrust, traction and weight.

4. PS Szcześniak solution

As the example of the solution of the intermediate frame for special vehicles operated in terrain the construction presented in Fig. 5 has been developed by PS Szcześniak company.

It has been tested by the stationary test and dynamic test. The results can be observed in Figs. 6 and 7.

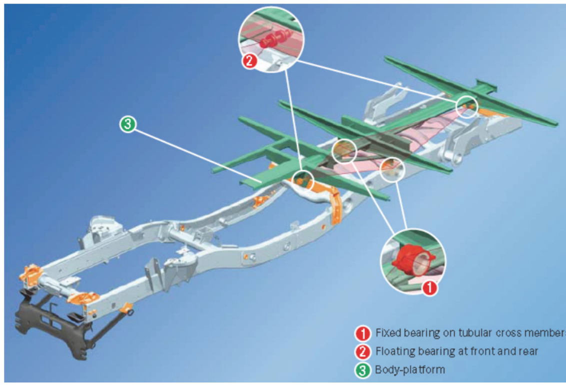


Fig. 4. Twist and strain-free mounting of aggregates and superstructures due to double 3-point mounting [13]

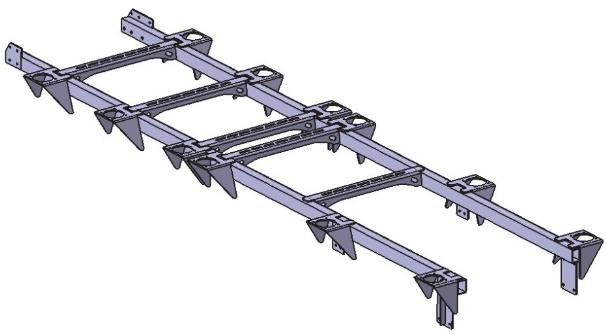


Fig. 5. Intermediate frame – PS Szcześniak solution [14]

Fig. 6. The dynamic test of special vehicle in terrain (off-road) [14]

Fig. 7. The stationary test on 30° axle articulation [14]

5. Conclusions

The vibration phenomena in heavy vehicles are an important issue. As far as dynamic responses isolation in cabs is well recognized for the isolation of loads there are many investigations needed. The review of the solutions in constructions of the frames allows to made some assumptions for PS Szcześniak project in scope of research programme Demonstrator + Supporting scientific research and development works in demonstration scale, the title of the project is Develop High Mobility Wheeled Platform for special applications.

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